THE WESTINGHOUSE

AIR BRAKE COMPANY,

PITTSBURGH, PA., U. S. A.

INSTRUCTION BOOK.

THE QUICK ACTION AUTOMATIC BRAKE.

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PITTSBURGH, PA.
1893.

PREFACE.

THE present edition of our Instruction Book, as will b[e] noted in the following pages, is almost wholly devoted to a[n] [a]nalysis and description of our new Quick Action brak[e] [m]echanism and kindred appliances which modern demand ha[s] [m]ade necessary in the safe operation of railway trains.

With the introduction of the original Westinghouse brake [c]ommonly known as the non-automatic, or "straight air" [b]rake, a degree of safety in the movement of railway train[s] [w]as made practicable beyond anything previously attained [a]nd for a time answered the requirements of train braking a[s] [t]hen understood.

Greater safety, as well as other conditions, demanded a [b]rake, automatic in its character to the extent of possessing [f]unctions in its operation that would to the greatest degree [p]rovide against human fallibility. The introduction of th[e] [a]utomatic air brake into general railway service met with mor[e] [o]r less opposition, purely upon the ground that "the 'straigh[t] [a]ir' brake was good enough;" but this objection rapidly dis[a]ppeared, as the automatic brake became better understoo[d] [a]nd its value as compared with the older form appreciated [a]nd the "straight air" brake is now almost wholly obsolete.

Time and progress in the art of railway operation, how[e]ver, have developed new conditions and requirements in trai[n] [b]raking, which this Company has fully met, as has been prac[ti]cally demonstrated, by the introduction of the new Quic[k] Action Automatic form of brake mechanism, which will b[e] [f]ound illustrated and clearly explained in this book.

While *it may* be said that a somewhat greater degre[e] [i]*ntelligence and* skill is required to understand its cor

tion, and to operate the new mechanism, yet the app which it is composed have been designed to compens as possible for the lack of these human traits, and it is that the infinite superiority of the new automatic br the old, will fully compensate its users for the troubl cating themselves to the new conditions, the attai which we are quite sure will not require the patien many will recall was necessary when substituting matic for the "straight air" brake. Local prejudice be found now, as then, against the new automati but they will be shown after a season, to l usually encountered by any innovation, and will with a better knowledge of the new mechanism.

These are facts that have been demonstrated af two years experience with the new apparatus which supplied almost exclusively upon orders for brakes du period.

This company has in its employ a large corps o tent men, whose services are at the disposal of our for a reasonable time without charge, to superintend t cation of sample sets of brake apparatus to locomot cars, and to assist in the education of railway em their operation and maintenance. We shall also be to provide designs for the brake gear of locomotives upon application, if furnished plans of the vehicl experience enabling us to make designs of a chara adapted to the vehicle for which they are intended, a will give the best service with a minimum of cost f tenance.

For convenience of reference, the cuts of the ap in greater detail than heretofore published, will be f the folded sheets in the pocket attached to the cove book, from which they may be removed, facilitating *tion, and renewal* when necessary.

E WESTINGHOUSE IMPROVED QUICK ACTION AUTOMATIC BRAKE.

HE Westinghouse Improved Quick Action Automatic Brake consists of the following essential parts :

1st. THE STEAM ENGINE AND PUMP, which furnishes e compressed air.

2d. THE MAIN RESERVOIR, in which the compressed air stored.

3d. THE ENGINEER'S BRAKE AND EQUALIZING DIS-ARGE VALVE, which regulates the flow of air from the main servoir into the brake pipe for releasing the brakes, and m the main train or brake pipe to the atmosphere for plying the brakes.

4th. THE MAIN TRAIN OR BRAKE PIPE, which leads m the main reservoir to the engineer's brake and equaliz-g discharge valve, and thence along the train supplying the paratus on each vehicle with air.

5th. THE AUXILIARY RESERVOIR, which takes a sup-y of air from the main reservoir, through the brake pipe, d stores it for use on its own vehicle.

6th. THE BRAKE CYLINDER, which has its piston rod ached to the brake levers in such a manner that, when e piston is forced out by air pressure, the brakes are plied.

7th. THE IMPROVED QUICK ACTION AUTOMATIC TRIPLE LVE, which is suitably connected to the main train pipe, xilliary reservoir and brake cylinder, and is operated by e variation of pressure in the brake pipe (1), so as to admit *from the auxiliary* reservoir (and under certain desirable con-*ons, as will be* explained hereinafter, from the train pipe

to the brake cylinder, which applies the brakes, at the san time cutting off communication from the brake pipe to tl auxiliary reservoir, or (2) to restore the supply from the tra pipe to the auxiliary reservoir, at the same time letting the a in the brake cylinder escape, which releases the brakes.

8th. THE COUPLINGS, which are attached to flexible ho and connect the train pipe from one vehicle to another.

9th. THE AIR GAUGE, which being of the duplex pa tern, show simultaneously, the pressures in the main reservo and the train pipe.

10th. THE PUMP GOVERNOR, which regulates the su ply of steam to the pump, stopping it when the maximum a pressure desired has been accumulated in the train brake pip and reservoirs.

These parts are illustrated in continuity on Plate 1, Fig 1, the arrangement being substantially as used on railwa trains.

The automatic action of the brake is due to the construc tion of the triple valve, the primary parts of which are a pis ton and slide valve. A moderate reduction of air pressur in the train pipe causes the greater pressure remaining store in the auxiliary reservoir to force the piston of the triple valv and its slide valve to a position which will allow the air in th auxiliary reservoir to pass directly into the brake cylinder an apply the brake. A sudden or violent reduction of the air i the train pipe, produces the same effect, and in addition t this, causes supplemental valves in the triple valve to b opened, permitting the pressure in the train pipe to also ente the brake cylinder, augmenting the pressure derived fro he auxiliary reservoir about 20 per cent., producing pro

cally instantaneous action of the brakes to their highest efficiency throughout the entire train. When the pressure in the brake pipe is again restored to an amount in excess of that remaining in the auxiliary reservoir, the piston and slide valve are forced in the opposite direction, to their normal position, opening communication from the train pipe to the auxiliary reservoir, and permitting the air in the brake cylinder to escape to the atmosphere, thus releasing the brakes.

If the engineer wishes to apply the brake, he moves the handle of the engineer's brake valve to the right, which first closes a port, retaining the pressure in the main reservoir, and then permits a portion of the air in the train pipe to escape. To release the brakes, he moves the handle to the extreme left, which allows the air in the main reservoir to flow freely into the brake pipe, restoring the pressure and releasing the brakes. A valve called the CONDUCTOR'S VALVE is placed in each car, with a cord running throughout the length of the car, and any of the trainmen, by pulling this cord, can open the valve, which allows the air to escape from the train pipe, applying the brake. When the train has been brought to a full stop in this manner, the valve should then be closed. Should the train break in two, the air in the brake pipe escapes and the brakes are applied instantaneously to both sections of the train. The brakes are also automatically applied should a hose or pipe burst. It will therefore be seen that ANY REDUCTION OF PRESSURE IN THE TRAIN PIPES APPLIES THE BRAKES, which is the essential feature of the automatic brake.

An angle cock is placed on each end of the train pipe, *and is closed before* separating the couplings, thus preventing *the application of* the brakes when cars are uncoupled.

stop cock is also placed in the branch pipe leading from th main train pipe to the quick action triple valve, and one i the main train pipe near the engineer's brake valve, and wit in convenient reach of the engineer. The former is for th purpose of cutting out or rendering inoperative the brake o any particular car which may have become disabled throug damage, and the latter for cutting out the engineer's bra valve upon all but the leading engine, where two or mo engines are coupled in the same train. It is desirable to u the old style plain automatic triple valve for locomotive driv and tender brakes, and its illustration in this connection w be noted in Plate 1, Figure 1, and in greater detail in Figur 3, 4 and 4*a*.

Following will be found details and descriptions o detached portions of the apparatus, with complete instructio for its proper use and maintenance, and general data hereto fore unpublished.

Mechanically, the engineer's brake and equalizing di charge valve provides for a lack of skill in so far as device can be made automatic, but it is essential that engineer should be possessed of a degree of skill and ju ment which will enable him to operate the brakes of his t in a judicious manner, by using them with care and mode tion in making ordinary stops, and only in case of ac emergency to make a quick application. The attention of engineer is therefore especially directed to the descriptio *the new engineer*'s brake and equalizing discharge valve, *the instructions* relating to the proper method of oper *the quick action* automatic brakes.

THE AIR PUMP.

HE construction of the air pump is clearly shown in
. cross-section in Plate 2, Fig. 5. A steam cylinder 3 and air
linder 5, are joined together by a center piece 4, which
rms the bottom head of the steam cylinder and the top
ad of the air cylinder, while suitable stuffing boxes 56,
erein encircle the piston rod 10, the lower end of which is
ached to air piston 11, and the upper end to the steam
ston, each of which is provided with suitable packing rings.
itably arranged valves in the walls of the steam cylinder 3
d its upper head 2, to which further reference will be
ade, admit steam alternately above and below the steam
ston 10, forcing it upward and downward, giving a similar
ovement to the air piston, while air from the outside atmos-
ere is drawn alternately through the air inlets and receiv-
g valves 31 and 33 and forced under pressure through the
scharge valves 32 and 30, into chamber *S*, and thence to the
ain reservoir through pipes connecting at the union swivel 53.

The main steam valve 7 is formed of two pistons of un-
ual diameter, mounted upon opposite ends of a rod, the
per one occupying cylindrical bushing 25, and the lower,
shing 26, each of these bushings having two series of port
les for the admission of steam to, and its exhaust from the
eam cylinder by a reciprocating movement of the main
lve. Connection with the source of steam supply is made
the union nut 54, and with steam in chamber *m*, the
ndency of the main valve on account of the greater dia-
eter of its upper piston is to move upward, thus providing
r *its upward* movement and for the admission of steam to
upper side of the steam piston 10, and its exhaust from

the lower side. The opposite, or downward movemei accomplished at the proper moment by the combined acti steam pressure upon the upper surface of the lower pistc the main valve and reversing piston 23, the stem of the extending through the bushing 22 in which it operates, bearing upon the top of the main steam valve. Pressur on the upper side of reversing piston 23 is regulated small slide valve 16 in the central chamber e of the steam cylinder head 2, to which steam pressure is cond from chamber m through port h. This valve is given m by a rod 17, which extends through bushing 19 in the head and into the hollow main piston rod 10, and is pro with a button head on its lower end and a shoulder n jus low the top head, the plate 18 on the steam piston altern strikes this shoulder and button head as the steam pisto approaches the top or bottom head of the steam cylinder.

Steam from the boiler being admitted to chamb forces the main valve upward, which uncovers the series of ports in bushing 25 and entering the steam cyl above the main piston 10, drives it downward, while used on the previous upward stroke is discharged fron under side of the lower main valve piston through the series of ports in bushing 26, which were also uncovere this upward movement of the main valve, thence throu suitably arranged passage f^1 f^1 shown in dotted lines municating with exhaust chamber g, whence it is disch by a pipe connected at union swivel 57, through the s box and stack to the atmosphere. As the main p reaches the termination of its downward stroke, plat striking the button head on the lower end of the re

valve rod 17, draws the rod and its valve 16 downward, uncovering port *a* in the upper head and admitting steam above reversing piston 23, which forces it and the main valve 7 downward to the position shown in the cut, and permits steam from above the main piston 10 to be discharged through the upper series of port holes in bushing 25, thence through passage *ff* to exhaust chamber *g* and the atmosphere, while live steam is admitted from chamber *m* through the upper series of ports in bushing 26 to the under side of main piston 10, driving it upward until plate 18 strikes the shoulder *n* of reversing rod 17, which pushes valve 16 upwards, and brings the small exhaust cavity in its seat opposite ports *b* and *c*, exhausting the pressure from above reversing piston 23 into exhaust passage *f f*, which permits the main valve to again move upward as previously described.

The upward movement of air piston 11, causes the lower receiving valve 33 to lift and air to be drawn through the series of inlet ports in the under side of the valve chamber cap 34, thence past the valve and through port p^1 to the cylinder; the downward movement of the air piston closes receiving valve 33, and compresses the air contained in the cylinder to a point in excess of that which may already be stored in the main reservoir, which lifts discharge valve 32, and permits the compressed air to flow into chamber *s* and to the main reservoir through pipes connected at union swivel 53. The downward movement of the air piston similarly causes air to be drawn into the upper end of the cylinder through the upper air inlet ports to chamber *v* through upper receiving valve 31 and passage *p*. The air on this side of the air piston in being compressed during the upward stro

closes the receiving valve and raising upper discha
30, is forced into chamber *t*, and thence through co
tion port *r* to chamber *s* and the main reservoir.

The lift of the receiving valves should be *$\frac{5}{32}$ of
and that of the discharge valves *$\frac{1}{8}$. It is most impo
the prescribed amount of lift of air valves be mainta
if exceeded by wear from action, which will ultimate
should not be permitted to become excessive, in whi
valves and seats may both be ruined, by pounding u
other, while prompt attention may save both, and
disagreeable pounding.

In renewing bushing 43, the shoulders upon whic
in position should be carefully ground in to preven
of air past these, then adjust set screw 46, when ca
may be screwed firmly, but not harshly, upon it.

With 125 pounds steam pressure, the 8-inch pu
in good condition will compress 0 to 70 pounds press
in a standard main reservoir 26½ in. diameter by 34
(outside measurement), about 9 cubic feet capaci
seconds, and from 20 to 70 pounds in 62 seconds.

The efficiency of the pump and its condition m
fore be readily ascertained at any time desired.
reservoirs are used than of the dimensions given,
may be calculated in exact proportion.

*For the Six Inch Pump, Plate B6, 1886 Catalogue, the Receiving Val
1-8th inch lift, and the discharge Valves 1-16th.

The Quick Action Triple Valve.

A PERSPECTIVE view of the arrangement of the auxiliary reservoir, passenger car brake cylinder, air pipes and quick ction triple valve (the latter in cross section and mounted on ıe front cylinder head), is shown in Fig. 8, Plate 3. A larger iew of the triple valve in cross section, is shown in Fig. 9, a ·ansparent view of the slide valve in Fig. 9*a*, and of the slide alve seat in Fig. 9*b*, to which references will be made in the ›llowing explanation of its purpose and functions.

The quick action triple valve is wholly automatic in prin- ıple, that feature existing in the construction of the plain ıtomatic triple valve by which its mechanism could be "cut ut" or made inoperative, or permitting the use of the straight air" or non-automatic form of brake, being entirely mitted.

As its name implies, the quick action triple valve is .esigned to facilitate rapidity of action of the brakes upon ailway trains, particularly those of considerable length, where lesired. Simultaneous action, as nearly as possible, is quite ıecessary to avoid shock consequent upon link or drawbar lack between cars. Such action, however, is only necessary n an emergency, its ordinary action for service applications ›f the brake being in entire harmony with that of the old style riple valves, either method of application being entirely de- ›endent upon the rapidity with which the air is discharged 'rom the train pipe, and consequently under the control of the ›ngineer. Under each car in the main train pipe is a drain ›up forming a tee, from which a branch pipe extends to the riple valve, to which it is connected at A, and a stop-cock is laced in this branch pipe for the purpose of rendering inc

erative the brakes upon any particular car when occasion requires, by reason of accident to the brake gear or apparatus, leaving the main train pipe unobstructed to supply air to the remaining vehicles. The opening. *B*, communicates with a chamber in the cylinder head, from which a pipe leads to the auxiliary reservoir. The opening, *C*, communicates with a port in the cylinder head through which air is conducted to and from the brake cylinder. Air from the main reservoir on the engine, being discharged into the train pipe by the operation of the engineer's brake valve, enters the triple valve at A, and passes thence through ports *e e* and *g g*, to piston chamber *h*, forcing the piston 4, to the normal position shown, which it occupies when brakes are released, uncovering feed port *i*, permitting the air to pass by the piston, thence through port *k* to chamber *m*, occupied by the slide valve 3, from which it has free egress at opening *B* to the auxiliary reservoir, charging the latter to the same pressure as that in the train pipe.

That portion of the stem of the piston 4 between the shoulders *u* and *c* is semi-circular in form, and passes between two flanges of the slide valve 3, the length of the latter being slightly less than the distance between these shoulders, permitting a limited movement of the piston without moving the slide valve. The arrangement of the ports in the latter will be clearly understood by reference to the transparent view in Fig. 9a. It will also be observed that a corner of the slide valve opposite ports *s* and *z* is cut away, for reasons that will appear later. A graduating valve, 7, is attached to and moves with the stem of the piston 4, and extends into a suitably made recess in the slide valve, opening and closing port *z* in the slide valve. Under ordinary conditions of operating

brakes, by a slight reduction of pressure in the train pipe, the movement of piston 4 in cylinder *h* is limited to the distance between the knob *j* and the end of the graduating stem 21, the spring 22 resisting further movement, but which may be compressed by the piston, permitting the latter to traverse the entire length of cylinder *h*, if a rapid discharge of 10 to 12 pounds pressure or more, is made from the train pipe.

To apply the brakes gently, a slight reduction of 6 to 8 pounds pressure in the train pipe is made, causing the greater pressure remaining in the auxiliary reservoir, with which chamber *m* is in constant communication, to force piston 4 to the right, closing feed port *i*, and moving the graduating valve away from its seat in port *z*, until the shoulder *u* on the piston stem, engaging the slide valve 3, moves it with the piston until the latter is stopped in its traverse, by knob *j* meeting the graduating stem 21, the spring 22 resisting further movement. In this position, port *z* is opposite port *r* in the valve seat, and air from the auxiliary reservoir passes into the brake cylinder through ports *w*, *z*, *r*, *r* and *C*, forcing the piston outward and applying the brakes. The pressure in the auxiliary reservoir having now been reduced by expansion into the brake cylinder to an amount slightly less than that in the train pipe, piston 4 is forced to the left and graduating valve 7 to its seat, closing port *z*, the slide valve remaining stationary, retaining the pressure in the brake cylinder. Further reductions of pressure in the train pipe, as may be desired to apply the brakes with greater force, causes the piston 4 to again move to the right against graduating stem 21, pulling graduating valve 7 from its seat, admitting additional pressure from the auxiliar reservoir to the brake cylinder until entirely equalized in ea

or to about 50 pounds, from an original pressure of 70 po in the auxiliary reservoir. This effect is caused by a redu of air pressure in the train pipe of about 20 pounds, which it will be seen that any further reduction is a was air, and that the force with which the brakes may be ap is proportionate to the reduction of pressure in the train within this limit.

The brakes are released by admitting pressure to the pipe, which forces piston 4 to the left to the position sh permitting pressure in the brake cylinder to escape to atmosphere through ports *C*, *r*, *r*, and exhaust ports *n* an the latter being cored to the atmosphere around the body.

The action of the brakes just described is that us ordinary station stoppages, and is termed a "service apr tion," and is caused, as will have been observed, by a gra discharge of pressure from the main train pipe at the en

To apply the brakes with their full force, a quick re tion of the pressure in the train pipe of 10 to 12 poun made, causing the piston 4 to move through the entire le of its cylinder *h*, compressing graduating spring 22, and b ing port *s* in the slide valve opposite port *r* in its seat, ac ting pressure from the auxiliary reservoir to the brake cyli at the same time the removed corner of the slide valve fore referred to, uncovers port *t* in its seat, admitting auxi reservoir pressure above piston 8, forcing it downward, emergency valve 10 from its seat, while train pipe pres lifting check valve 15, rushes to the brake cylinder thr the openings made, in a large volume, uniting with that he auxiliary reservoir, giving a pressure on the pi

about 60 pounds per square inch, from 70 pounds auxiliary reservoir and train pipe pressure, or about 20 per cent. greater than from a service application of the brakes. The check valve 15 closing when the pressure is equalized, prevents pressure from the brake cylinder re-entering the train pipe. A restoration of pressure in the train pipe releases the brakes, as already described, port *t* being brought into communication with exhaust port *n* of the slide valve, permitting the air used in forcing piston 8 downward to escape to the atmophere, and spring 12 then restores emergency valve 10 to its seat. This action of the brake apparatus, as will have been noted, causes a local reduction of train pipe pressure under each car, by discharging this air into the cylinder for braking purposes, instead of having it to wholly pass to the atmosphere at the engine, as was necessarily the case with the plain form of automatic brake apparatus, economizing in the use of air pressure and producing, practically instantaneous action of the brakes throughout an indefinite length of train, but they should be used in this manner in cases of emergency only.

To prevent the application of brakes from a slight reduction of pressure caused by leakage in the train pipe, an oval groove is cut in the bore of the car cylinder $\frac{9}{64}$ of an inch in width and $\frac{5}{64}$ of an inch in depth, and of such length that the piston must travel three inches before the groove is covered by the packing leather. A small quantity of air, such as results from a leak, passing from the triple valve into the brake cylinder, may have the effect of moving the piston slightly forward, but not sufficiently to close the groove, which permits the air to flow to the atmosphere past the piston. If, however, the brakes are applied in the usual manner the pisto

will be moved forward, notwithstanding the slight leak, and will cover the groove. It is very important that the groove shall be of the dimensions given.

The triple valve should be drained occasionally of any moisture that may accumulate, by the removal of the bottom plug. In an "emergency" action of the brakes, when, as previously stated, air from the train pipe is vented into the brake cylinder, the strong current of air toward the triple valve carries with it any foreign matter in the air pipes, and which lodging in the conical strainer 16, at the union of the branch pipe and the triple valve, may clog the meshes of the strainer and prevent the free passage of air, and should therefore be cleaned occasionally, but which may be largely avoided if the hose, when not coupled to that on adjoining vehicles, is placed in its dummy coupling and the air pipes have been carefully blown out with steam previous to their erection on the car. Should a continuous leak manifest itself at the exhaust port of the triple valve, or the pressure retaining valve, it will usually be found to be due to the presence of dirt on the seat of the emergency valve 10, which should be cleaned.

On account of slight differences in sizes of ports, triple valves intended for freight or passenger car brakes must not be used in the opposite service. The passenger car triple valve having a letter *P* cast upon its body, may be readily distinguished from that intended for freight service.

The Plain Automatic Triple Valve.

A PERSPECTIVE view of the plain automatic triple valve and locomotive tender brake apparatus, is shown in Plate 1 Fig. 3, and cross sections of the triple valve in Figs. 4 and 4*a* which will clearly show its construction. It is desirable that this triple valve be perpetuated for use with locomotive driving wheel and tender brakes, to give a slightly slower action to the brakes thereon in cases of emergency action of the quick action apparatus on cars.

The construction and operation of the plain automatic triple valve is substantially the same as that of the quick action form, the quick action valves being omitted, and pressure used only from the auxiliary reservoir in applying the brakes, and will not, therefore, require specific description.

As constructed formerly, the handle, 15, could be turned from a horizontal position, which it occupies when the brakes are operated as automatic, to a vertical position, permitting the use of the non-automatic brake, but as this is now practically obsolete, a lug is cast upon this handle which permits it to be turned only to an intermediate position, in which the brakes are inoperative or shut off on that particular vehicle. To drain the cup 3 of moisture, slack the bottom nut 10 a few turns, let any water escape and screw it up again. A tender drain cup should invariably be located in the main train pipe on the tender to catch and retain moisture, which would otherwise pass to the train brake apparatus. A cock in this cup readily provides for letting out the moisture, which should be done frequently.

THE ENGINEER'S BRAKE AND EQUALIZING DISCHA VALVE.

THE Engineer's Brake and Equalizing Discharge sectional cuts of which are shown on Plate 2, Figs. 1 and a plan view in Fig. 3, with the cap nut 12 and valve 13 removed, is a device designed especially to as engineer in operating train brakes in a more perfect r than has hitherto been possible with the three-way c brake valves formerly used for this purpose, without co able personal skill from the operator.

It is of the greatest importance to perfect train b that a gradual exhaust or discharge of air pressure fr train pipe should be made in applying the brakes unde nary conditions of station stopping, and a gentle clos stoppage of this exhaust in order to thoroughly equal pressure remaining in the train pipe, thus preventing lease of some of the front brakes of the train, which n cur, particularly on long trains, by the abrupt openir closure of the ordinary three way cock, which causes a surge of air from the rear to the front end of the train, ing the brakes as stated. The brake valve here illustra tirely prevents this, and MECHANICALLY MEASURES TH UME OF AIR REQUIRED TO BE DISCHARGED FROM THE PIPE AND LIMITS THE RATE OF ITS DISCHARGE WHEN AP THE BRAKES FOR ORDINARY STOPPAGES, and is equally e on short or long trains. Large openings are provided construction for the instantaneous application of the in an emergency.

It is absolutely essential in operating the brakes up *rains, and is of* great importance on short ones, t

pressure of air in the main reservoir on the engine of twenty to twenty-five pounds greater than train pipe and auxiliary reservoir pressure, which will, when discharged into the train pipe, insure a prompt release of all the brakes. The absence of "excess" pressure in the main reservoir, or improper handling of the brakes, will sometimes retard their release, necessitating the partial "bleeding" of auxiliary reservoirs.

A full set of engine brake fixtures includes a pressure gauge having two sets of works, and two indicators (red and black) on a single dial, which shows at a glance the pressure respectively in the main reservoir and train pipe, the connecting pipes being attached to the brake valve at *R* and *W*. The air pipe to the pump governor should be connected at *V*, the main reservoir pipe at *X*, and train pipe at *Y*.

By preparing a diagram similar to Fig. 4, representing the rotary valve 13 and handle 8, of tracing cloth or other transparent material, cutting the ports *a* and *j* out of the diagram on their boundary lines to show THROUGH openings, and then reversing same and placing it upon the seat of the valve, Fig. 3, where it may be rotated at will on its center, the explanation following will be made clear. For convenience of illustration such a diagram is already mounted on a card and accompanies this book.

By reference to cuts of the valve, it will be seen that movement of the handle 8, on which is located a spring 9 for guiding it to position, operates "rotary valve" 13 upon its seat, opening and closing the various ports as required.

When the handle 8 is in "position for releasing brake" *air from the* main reservoir entering the brake valve at X *passes through* "supply ports" *a* and *b*, thence upward i

cavity *c*, in the under surface of the rotary valve 13, th through "direct application and supply port" *l* to the pipe *Y*. While yet in this position, port *j* in the rotary valve a port *e* in its seat are in communication, and air passes in chamber *D* above piston 17, thence through port *s* to a sm reservoir, which is usually suspended under the right runni board of the engine, pipe connections being made therewi at *T*. This reservoir serves the purpose of increased volu of space to chamber *D*.

The handle 8 now being placed in "position while running DIRECT communication between the train pipe and main res voir ceases, and port *j* is brought opposite feed port *f*, throu which main reservoir pressure now passes to the under side the "feed valve" 21, which latter is held to its seat by "fe valve spring" 20 having a resistance of about twenty poun When this additional pressure is accumulated in the ma reservoir, "feed valve" 21 is forced open, the air passi thence through "feed port" f^1 to port *l* and the train pi while train pipe pressure is maintained in chamber *D* throu port *l*, cavity *c* and "equalizing port" *g*, thus equalizing t pressure above and below piston 17, the stem of which, for ing a valve, is seated in the position shown in "bottom cap" and permits the escape of air from the train pipe to the atm phere through ports *m* and *n* when raised from its seat.

When applying brakes for ordinary or station stops, mo handle 8 to "on lap" position. This blanks all ports in t rotary valve and seat. Then moving the valve handle to t position "application of brake, service stop," the small exha cavity *p* in the lower surface of the rotary valve 13, establis communication between the two "preliminary exhaust po

e and *h*, the latter leading to the atmosphere, and after discharging about 8 pounds pressure as shown by the gauge, restore the handle to "on lap" position. This preliminary discharge of air from chamber *D* will cause the piston 17 and its stem to rise, which operation is followed by a discharge of air from the train pipe to the atmosphere through ports *m* and *n*, applying the brakes gently. This discharge of air from the train pipe CONTINUES AFTER THE VALVE HANDLE IS CARRIED TO "ON LAP" POSITION (gradually equalizing train pipe pressure) AND UNTIL THE TRAIN PIPE PRESSURE HAS BEEN REDUCED SLIGHTLY LOWER THAN THAT YET REMAINING IN THE CHAMBER ABOVE THE PISTON, when the latter is forced downward and its stem to its seat, closing the outlet *n*, and preventing the further escape of air, until the operation is repeated, which may be necessary to apply the brakes with the desired degree of force.

To throw off brakes, push handle 8 to "position for releasing brakes," causing the excess air pressure in the main reservoir to be discharged into the train pipe, insuring their prompt and certain release.

For an "emergency" application of brakes, push the handle to the extreme right, to position "application of brake emergency stop." This operation establishes direct communication between the train pipe and the atmosphere, through the "direct application and supply port" *l*, cavity *c* and the "direct application and exhaust port" *k*, applying the brakes with their full force instantly.

When handling trains on down grades, let the brake valve handle remain in full release position, except when applying brakes, which will insure the full and prompt recharging of auxiliary reservoirs under cars.

If the engineer's brake valve bracket is to be located against the boiler head, it must be made of sufficient length to prevent injury to the valve gaskets by heat. After being placed in position on the engine, and before using, it is a good practice to remove valve 13 and wipe its face and seat quite clean of any grit that may have lodged thereon in transit; rub a LITTLE tallow on the surfaces, and replace. Care in this respect will prevent the valve and seat from cutting. Any leakage between the valve and seat may result in establishing communication between the several passages or ports therein, and thus prevent the very desirable results for which the valve was particularly designed. When this occurs it is necessary to regrind valve 13, which may be done by carefully facing and scraping the surfaces to a good seat, after which use a SMALL quantity of fine ground glass, sieved through cloth of close texture, and a little oil. Usually the valve only requires facing.

It is of the utmost importance that DIRECT CONNECTION BE MADE FROM THE ENGINEER'S BRAKE VALVE TO THE MAIN RESERVOIR, instead of connecting to the discharge pipe leading from air pump to main reservoir. The latter practice is very undesirable, as a great deal of moisture and oil is discharged into the train brake system which would otherwise be deposited in the main reservoir from which it can be readily drained.

A one inch stop cock should be placed in the train pipe, a short distance below the engineer's brake valve within convenient reach of the engineer, and should be closed upon all but the leading engine of a train, where two or more engines are coupled in the same train, in order that the head engine may operate the train brakes.

It is important that the pipe connections to the brake valve be PERFECTLY AIR TIGHT, and that the valve should occasionally be cleaned. The feed valve 21 can be readily removed for cleaning by the engineer, by placing the valve handle in "emergency" application position, which will retain the air in the main reservoir, then unscrewing cap nut 19. This should be done occassionally, as any derangement of its functions of maintaining an excess pressure in the main reservoir is usually found to be due to the presence of dirt, or gum from the use of too much oil or lubricant of an inferior quality. The piston should also be removed for cleaning, at intervals, as the presence of gum interferes with its free movement.

ADDENDA.

REGARDING THE ENGINEER'S BRAKE AND EQUALIZING DISCHARGE VALVE.

TO THOSE unfamiliar with mechanical drawings the construction of the engineer's brake and equalizing discharge valve, as illustrated on Plate 2, Figs. 1, 2 and 3, may appear somewhat complex, and in consequence of this a more or less imperfect knowledge of its important functions is had, where it is very desirable that it be thoroughly understood, and that the reasons for using a valve of this character be fully appreciated in order that very desirable results may be had, which are not to be obtained with the ordinary three-way cock in the operation of the automatic brake.

We have, therefore, prepared a simple diagram illustrative of the functions of the engineer's brake and equalizing discharge valve, which is printed upon a card and accompanies this work, and in which the several ports or air passages necessary in the brake valve, as actually constructed, are shown as nearly as possible on a PLANE surface, while the transparent disc or handle mounted on the diagram may be likened to the plug or key of a three-way cock in which are arranged suitable ports that, when brought opposite others in the surrounding body by the movement of the handle to corresponding positions, in which the brake valve handle would be placed in actual practice, will no doubt serve to make clearer the purposes of the brake valve and to show the

aportance and necessity of the device. The lower portion of ie diagram, containing the piston 17, and the parts below it, 'e arranged as actually constructed in the brake valve, Figs. 2 and 3.

Assuming that the pipe to the main reservoir is connected *X*, the train pipe at *Y* and the pipe to small equalizing res-'voir at *T*, it will be seen by placing the handle of the valve POSITION FOR RELEASING, that ports *a*, *b* and *l l* are oppo-te each other, permitting air to flow freely and directly from ie main reservoir to the train pipe for releasing brakes and iarging auxiliary reservoirs. Ports *d*, *i* and *e e* are at the ime time in communication with each other, permitting air › flow into chamber *D*, above piston 17, and thence through ort *s s*, into and charging the small reservoir, which latter is itended to contribute to chamber *D* a larger volume of air han is actually contained therein, because, as will be seen later n, pressure is exhausted from chamber *D* in applying brakes, vhen the greater pressure on the under side of piston 17 orces the latter upward, opening the train pipe to the atmos-›here through ports *m* and *n*, while if chamber *D* con-ained only a small volume or quantity of air, this would be ›ntirely discharged to the atmosphere in a moment, resulting n the full application of the brakes, but by using the small 'eservoir this undesirable effect is avoided, and the brakes may ›e applied with any desired degree of severity to their greatest effect.

Having charged the train pipe and auxiliary reservoirs o, say, 70 pounds pressure, move the valve handle to "POSI-*TION WHILE RUNNING*." Port *b* does not now communicate *ith port l, and air* must therefore flow indirectly to the tra

pipe through ports *a*, *b*, *c* and *ff*, forcing valve 21 from its seat, thence through ports f^1 f^1 to port *l* and the train pipe, but before it can do so 20 to 25 pounds excess air pressure must be accumulated in the main reservoir to force valve 21 from its seat, its movement being opposed by a spring having a resistance of about 25 pounds. Ports *a*, *i* and *e e* are still in communication, thus maintaining pressure in chamber *D* and small reservoir.

To apply the brakes gently, the handle being moved to "LAP," BLANKS or closes all ports and connecting passages, and a further movement to the "SERVICE STOP" position permits air to flow to the atmosphere from the small reservoir and chamber *D*, say reducing the pressure 6 to 8 pounds by the gauge, through ports *e e*, *c*, *b*, *p* and *h*, when handle may be returned to "LAP." This reduction of pressure, ABOVE piston 17 causes the greater or train pipe pressure, acting on its under side, to force it upward, lifting its stem, the lower end of which forms a valve, from its seat, permitting air from the train pipe to be exhausted to the atmosphere through ports *m* and *n*, and the angle fitting from which a pipe may be extended outside of the cab, and through which train pipe pressure will continue to exhaust UNTIL THE PRESSURE IN THE TRAIN PIPE HAS BEEN REDUCED TO THAT YET REMAINING IN CHAMBER *D*, when the piston is forced downward, AUTOMATICALLY CLOSING the exhaust outlet. This is one of the important functions of this valve, BECAUSE A UNIFORM REDUCTION OF PRESSURE IS EFFECTED GRADUALLY THROUGHOUT THE ENTIRE LENGTH OF TRAIN PIPE, whether it be that of an ordinary passenger train of a few cars or a long freight train, preventing the possibility of the release of brakes upon some of the cars at the forward end of

the train when they should remain applied, which may occur by the use of an ordinary three-way cock by means of the abrupt stoppage of the discharge of air from the train pipe at the engine in applying the brakes causing the air yet comparatively undisturbed in the rear end to rush forward with considerable impulse, affecting the forward brakes as before stated.

Returning handle to "POSITION FOR RELEASING" permits the excess pressure already accumulated in the main reservoir, to be discharged into the train pipe, insuring the prompt release of all the brakes and recharging of auxiliary reservoirs.

A quick or "emergency" application of the brakes to their fullest extent is had by moving the handle to "EMERGENCY STOP" position, when the large ports, *l l*, *c*, *b* and *k*, are brought into communication, causing a rapid discharge of air, in considerable volume, from the train pipe to the atmosphere and brake cylinders, which causes instantaneous action of the brakes to their maximum power on the entire train.

THE PUMP GOVERNOR.

The construction of the pump governor is illustrated in cross section, in Plate 2, Fig. 7. Its purpose is to automatically shut off the supply of steam to the pump when the air pressure in the train pipe and auxiliary reservoirs has reached the limit allowable, say 70 pounds, this pressure forming the basis upon which the maximum power of the brake gear used on cars and engines is designed, thus avoiding excessive air pressure, which used indiscreetly will result in sliding wheel

With a judicious use of the brake, and maintenance of pressure to the maximum allowable, sliding of wheels may be wholly avoided.

The simplicity of construction of the governor is such, that the following description of its mechanism will make it readily understood.

By reference to Plate 1, Figs. 1 and 2, it will be seen that suitable provisions are made for attaching the end, *Y*, of the governor, directly to the steam pipe union connection of the air pump, the opposite end, *X*, being piped to the source of steam supply. Another pipe connection, with union swivel 21, at *W*, is also made and extended to the fitting 30, Fig. 2, Plate 2, in the engineer's brake valve. This fitting it will be observed is tapped into a port of the brake valve, WHICH IS ALWAYS IN DIRECT COMMUNICATION WITH THE TRAIN PIPE, THE PRESSURE TO BE GOVERNED, and which acting upon the under side of the flexible diaphragm, 19, forces it upward against the resistance of the regulating spring, 18, when the desired train pipe pressure has been reached, lifting valve 17 from its seat, admitting air pressure on top of piston 5, forcing steam valve 9, with which it is connected by stem 7, to its seat, shutting off the supply of steam. A reduction of air pressure in the train pipe by applying brakes, causes a reverse movement of the governor, valve 17 closing, and the pressure contained in the chamber above piston 5 leaking away past its edges to the atmosphere through the exhaust connection 10, in cylinder 3. Spring 8 then forces the piston upward opening steam valve 9, and permitting steam to again pass to the pump. Any necessary adjustment of the regulating spring 18, is readily made by means of nuts 14 and 15.

General Arrangement of the Automatic Brake and Train Signaling Apparatus on a Locomotive and Tender.

THE general arrangement of the brake and signal appliances on a locomotive and tender is illustrated in Fig. 2, Plate 1, and clearly shows the arrangement of the pipes and apparatus thereon, which should be closely followed in attaching the apparatus, slight modifications possibly being necessary with different classes of locomotives. SEPARATE PIPES FROM THE AIR CYLINDER OF THE PUMP TO THE MAIN RESERVOIR, AND FROM THE LATTER TO THE ENGINEER'S BRAKE VALVE, SHOULD INVARIABLY BE USED. The practice that has been found to prevail in some quarters, of connecting the discharge pipe of the pump with the pipe leading to the engineer's brake valve is to be deprecated, and will cause the discharge of filth from the pump, directly into the train brake appliances.

The main reservoir capacity for passenger engines should be not less than 16,000 cubic inches, and for freight engines, not less than 24,000. If convenient space for a single main reservoir of the necessary capacity is not to be had on the engine, it is recommended that two smaller ones be used, giving opportunity for even greater air storage capacity than that indicated, with still better results. It is not a good practice to locate the main reservoir on the top of the tender, as moisture will accumulate in the pipes leading thereto, and ultimately find its way into the train brake appliances. It is invariably recommended that separate auxilary reservoirs be used for driver and tender brakes.

Attention is particularly called to the position of the cut-*out cock in the* train pipe just beneath the engineer's bra

valve, also shown in Fig. 1. This cock is necessary to cut out the engineer's brake valve upon all the engines coupled in a train, excepting that from which the train brakes are operated.

It is desirable that the plain automatic triple valve, shown in Figs. 3 and 4, Plate 1, be used on engines and tenders, giving a slightly slower movement of the brakes in full application, than of the car brakes.

GENERAL ARRANGEMENT OF THE AUTOMATIC BRAKE AND COMPRESSED AIR TRAIN SIGNALING APPARATUS ON PASSENGER EQUIPMENT CARS.

THE general arrangement of the Automatic Brake and Signaling Apparatus, as applied to a passenger equipment car, is illustrated in Fig. 1, Plate 3, in detail, readily enabling their erection in a correct manner.

It is of the greatest importance that the brake levers and connections be made of ample dimensions and the brake beams of sufficient stiffness to resist deflection or stretching, in order that the movement of the piston in the brake cylinder may be wholly utilized in forcing the shoes against the wheels, instead of compensating for such deflections by additional movement, which will necessarily occur from the employment of a weak and insufficiently staunch brake gear. The use of turned pins with large surfaces, and fitted reasonably close in holes of the brake gear, are quite desirable, reducing the lost motion to a minimum.

The Hodge System of levers, the proportions and dimensions of parts of which are given in minute detail in Plate 3, Fig. 7, is recommended for passenger cars, and should be arranged to develop a maximum pressure at the brake shoes of 90 per cent. of the weight of the car on the track under the wheels to which brakes are applied, based upon a pressure of 60 pounds per square inch in the brake cylinder, which gives a cylinder force of 4,700 pounds for the ten-inch cylinder, and 9,200 pounds for the fourteen-inch cylinder

this force being derived from an "emergency" action of th brakes, with 70 pounds pressure in the train pipe and auxiliar reservoirs. With the plain automatic triple valves, of whic there are large numbers yet in use, 50 pounds pressure is ha under the same conditions of service, giving a maximum forc of about 4,000 pounds on the piston of the ten-inch ca cylinder.

For convenience of adjustment of the braking force o cars of different weights, cylinder levers may be arranged wit a series of holes in their outer ends, and the amount of powe or force developed at the brake shoes by each, depending up on the hole in which the Hodge lever rod may be connectec should be stamped opposite each hole (or numbered), whil the permissable braking force, based upon the rule alread given (or corresponding number), should be stencilled upo the cross-bearers of each car by a competent authority, a shown, thus avoiding any confusion likely to arise by the us of a variety of cylinder levers as they have been usuall employed.

By carefully adjusting the brake gear in the manne described, and strictly limiting the air pressure to the authoı ized maximum, sliding of the wheels will be reduced to a min mum and the highest efficiency of the brakes obtained.

In erecting the apparatus, care should be taken to blo out all pipes with steam, after bending, and removing fins afte cutting.

The relative positions shown of the brake and sign pipes should be closely adhered to, in order that the hose ma be conveniently coupled with that on adjacent vehicles void chafing.

For six-wheel truck cars the brakes should invariably be arranged to act upon all of the wheels, the weight of the car being equally distributed upon these, in order that a braking force proportionate to their weight, as with four-wheel cars, may be employed. For this purpose a more powerful brake apparatus than that ordinarily used for four-wheel truck cars is necessary, a fourteen-inch cylinder being furnished. When it is considered that many through express trains are composed largely of heavy six-wheel truck cars, the necessity for a brake on them of the highest efficiency possible, will be quite apparent. Plans showing the general arrangement of the brake apparatus as applied to six-wheel truck cars will be furnished upon application.

The Driver Brake.

A GENERAL arrangement of the push-down form of cam driver brake as now commonly applied to two pairs of driving wheels of a locomotive, is shown on plate 2, Fig. 8. In this form of brake, the piston stuffing box is avoided, and the cams are highest above the rail when in release position, advantages not possessed by the pull-up form of driver brake. On Plate 2, Fig. 6, is shown the usual form of driver brake as applied to more than two pairs of driving wheels, the arrangement of levers and connections providing for practically perfect equalization of pressure at the brake shoes. The reasoning that driver brakes are a source of damage to the engine structure is erroneous, as has long since been demonstrated to the satisfaction of competent critics, and their value as an adjunct in train braking is unquestioned.

Suitable forms of brake shoes may be had, however, through which the braking force is expended upon the flange, and that portion of the tire outside of the rail seat, thus wearing that portion of the tire not touched by the rail, admitting of a much larger mileage being had from engines before the tire require returning, than is possible in the absence of driver brakes.

In order that the best results and highest efficiency attainable be had from the use of driving wheel brakes, it is of the greatest importance that the form best adapted to the engine be selected, carefully designed, and correctly applied. Long experience in this respect, it is believed, enables this company to correctly advise upon this subject and it is strongly urged that application be made to us for all such designs.

THE QUICK ACTION AUTOMATIC FREIGHT CAR BRAKE.

THE Cylinder, Auxiliary Reservoir and Triple Valve of the Quick Action Automatic Freight Car Brake are illustrated in Fig. 9, Plate 4. For convenience of erection these parts are arranged in combination with each other in compact form.

The triple valve is of the same essential construction as that used on passenger cars, but differs slightly in the proportions of some of its parts from the passenger triple valve, which latter may be readily recognized by the presence of a letter *P* cast upon its outside surface. FOR THIS REASON EITHER MUST NOT BE USED IN THE OPPOSITE SERVICE. The description of the mechanism of the quick action passenger triple valve also applies to the freight triple valve, the operation being the same, air pressure being conducted to the brake cylinder through the pipe *h*, which is fastened securely in and passes through the auxiliary reservoir. A push rod, shown in Fig. 12, Plate 4, is inserted in the hollow piston rod of the freight car brake, and is attached in a suitable manner to the brake gear. It will, therefore, be seen that in the application of the hand brakes this rod moves outward, leaving the piston undisturbed. A leakage groove *a*, the purpose of which has already been related in the description of the passenger car brake apparatus, is cut in the upper portion of the cylinder of the freight car brake as well. A release valve in the top of the reservoir 10, provides for the release of air therefrom when *desired.*

The Pressure Retaining Valve.

THE Pressure Retaining Valve, Fig. 10, Plate 4, is a vice for use only on long and steep gradients. This i weighted valve connected to the exhaust port of the tri valve with a suitable pipe; and is provided with a small cc the handle of which, in the horizontal position shown, wh it should be placed in descending long grades, allows the issuing from the exhaust port of the triple valve, when bra are releasing, to pass through port *b*, and to raise the weigh valve 20, passing thence to the atmosphere through the con shaped port *c*, $\frac{1}{16}$ of an inch in diameter at its smallest p The weighted valve 20, is of sufficient dimensions that a fc of 15 pounds pressure per square inch on the surface expc in port *b* is required to raise it, making it obvious that in position shown, 15 pounds pressure of air is retai in the brake cylinder, holding the train in check, while mechanism of the triple valves, being in release position, ables the prompt recharging of the auxiliary reservoirs. slight grades, or a level, the handle should be turned do bringing ports *b*, *a*, *e* in communication with each other, 1 mitting the free exhaust of air to the atmosphere with passing the weighted valve, and therefore entirely releas of the brakes.

THE GENERAL ARRANGEMENT OF THE AUTOMATIC BRAKE ON FREIGHT EQUIPMENT CARS.

THE general arrangement of the automatic brake mechanism, and system of levers, as applied to a freight car, is fully illustrated in Fig. 11, Plate 4.

Seventy pounds air pressure should be used, from which, with an "emergency" action of the apparatus, a maximum pressure of 60 pounds per square inch is had upon the piston, giving a total cylinder force of about 3,000 pounds. The maximum pressure exerted at the brake shoes for freight cars should not exceed 70 per cent. of the light weight of the car at the rails. Brake shoes should be suspended with their centers not lower than two inches below the center of the truck wheels. This will allow for a brake beam lever of reasonably low proportion, and for sufficient clearance of the under connections above the rail.

Iron brake beams are strongly recommended for use in connection with the automatic brake, in preference to the ordinary wooden ones, and the Master Car Builder's standard freight car brake gear, as illustrated in Fig. 12, Plate 4. Dimensions only of such parts as can be duplicated on any freight car are given. Others are omitted for the reason that they require considerable modification in essential particulars to suit cars of different construction. The apparatus should be attached to the car in a most secure and substantial manner, and while possibly at a slightly greater cost originally, future cost for repairs and maintenance will be reduced to a minimum.

Air pipes must be thoroughly blown out with steam after bending, fins removed, and carefully secured to the car framing to prevent the joints shaking loose. All joints should

thoroughly tested under air pressure by means of a solution of soap suds, which, if applied with a brush, will form a bubble where a leak exists. The pressure retaining valve should be located at the end of the car, and near the hand brake wheel, so as to be within easy reach of the brakemen; the joints of the pipe leading thereto must also be perfectly air tight.

The necessity for two hand brake staffs, as will be observed, does not exist on the ordinary freight car, as the brake gear, as usually arranged, provides for the application of the brakes upon both trucks simultaneously from one end of the car.

The quick action freight car brake being wholly automatic, cannot be changed to act with the non-automatic brake, but will operate in complete harmony with the plain form of automatic brake mechanism, furnished previous to the introduction of the new form. A cut-out cock located in the branch pipe leading from the main train pipe to the triple valve, provides for cutting out the apparatus in the event of accident to any of the parts. The brake is operative when the handle of this cock is set to right angles or cross-wise of the branch pipe, and is cut out or inoperative, when parallel, or in line with the branch pipe. It is highly important that the position of the appliances at the ends of the cars be arranged in accordance with the dimensions given, thus securing desired harmony in this respect on cars of this class, engaged in interstate traffic.

The angle cock in the train pipe at each end of the car is designed to facilitate the renewal of hose when necessary, and to obviate the possibility of its being closed by flying missiles under the train, the handle being in line with the train pipe when open, and cross-wise of the pipe when closed.

Train Signaling Apparatus.

THE compressed Air Train Signaling Apparatus is illustrated in Plate 3, Figs. 2, 3, 4, 5 and 6, and its arrangement and application to a locomotive is shown in greater detail on Plate 1, Fig. 2, and to a passenger equipment car on Plate 3, Fig. 1.

This apparatus is intended for the easy and certain transmission of signals from the train to the engineer, taking the place of the old bell cord, which, upon trains of any considerable length, is quite unsatisfactory.

A separate line of $\frac{3}{4}$ inch pipe extends throughout the entire train, and is united between the various vehicles with hose and couplings, the same as in the air brake system, but the couplings, being of slightly different proportions, CANNOT be united with the air brake couplings.

A Car Discharge Valve, Fig. 3, Plate 3, is located at some convenient position on each car, preferably above the door, and opposite the hole through which the old bell cord passed, and is connected by means of pipe to the main signal pipe under the car. A comparatively light cord passing through the car is attached to the lever of the car discharge valve, and, extending to the platform, is fastened in a suitable manner, enabling the use of the signal from any part of the car.

A Signal Valve, Fig. 4, Plate 3, may be attached by means of lugs on the upper cap, to the right running-board of the *engine under the* cab. Suitable pipe connections are made *with the main signal* pipe, and the signal valve at Y, and at

to the small signal whistle, Fig. 6, Plate 3, which latter may be located in some convenient place in the engine cab.

A Reducing Valve, Fig 5, Plate 3, usually screwed into the UPPER SIDE of the main air reservoir of the brake system, admits pressure therefrom to the signal pipe, to which it is also connected, reduced to 25 pounds pressure per square inch.

Signals are transmitted to the engineer from the train by pulling the signal cord on any car, thus opening the car discharge valve and causing a slight and short discharge of air, which reduces the pressure in the main signal pipe and its connections, and thus automatically operating the signal valve on the engine, air is discharged through a small whistle in the cab, sounding blasts corresponding to each pull of the cord from the train, and which may be given at the rate of one per second, a rule which should be generally observed, as too frequent and long discharges of air at the car discharge valve will somewhat confuse them. A little practice will soon enable the operator to make all necessary signals with entire accuracy.

In the Pressure Reducing Valve, spring 9 forces diaphragm 7 downward pushing valve 5 from its seat, permitting pressure to flow from main reservoir, to and charging the signal pipes. The resistance of spring 9 is such that when the signal pipe has been charged to 25 pounds pressure, this pressure, acting upon the exposed lower surface of diaphragm 7, forces it upward, and spring 10, pushing valve 5 to its seat, prevents further ingress of air until required by the operation of the signal. This valve should occasionally be cleansed of the gummy deposit sometimes found to collect on the working parts, which causes a sluggish operation, but which may be

largely avoided, if a good oil is sparingly used for lubricating the air cylinder of the pump, and if the main reservoir is drained at intervals of its accumulation of water and oil.

On the Car Discharge Valve, a compound lever, 5, to which the signal cord is fastened, when pulled, pushes open valve 3, permitting a small quantity of air to escape from the signal pipe, to a branch of which it is attached, causing the whistle to sound on the engine.

In the Signal Valve, the two compartments *A* and *B* are separated by a diaphragm 12, and the diaphragm stem attached thereto extends through bushing 9, its end forming a valve on seat 7, which prevents the egress of air to the whistle when seated. A small portion of the diaphragm stem 10 fits bushing 9 snugly, while just below its upper surface, a cylindrical groove is cut in the stem and its lower end milled in triangular form. Pressure enters the signal valve at *Y*, and passing through port *d*, fills chamber *A*, and through port *e*, past stem 10, fills chamber *B*. A sudden reduction of pressure in the signal pipe, reduces the pressure in chamber *A* on top of diaphragm 12, when the greater pressure in chamber *B*, acting on its under surface, forces it upward, momentarily permitting a portion of the air in the signal pipe and chamber *B* to escape to the whistle, giving a signal to the engineer.

It will be observed that a discharge of air from the signal pipe causes the whistle to sound on the engine, and it is therefore apparent that all signal pipes should be perfectly tight, otherwise signals may be given when not intended.

THE HODGE AND STEVENS SYSTEMS OF CAR BRAKE L

THE Hodge and Stevens Systems of Car Brake Lev shown in Figs. 7 and 8, Plate 4. The Stevens syst fers from the Hodge in that the floating or Hodge lever is interposed between the cylinder levers and the truc in the Hodge system) is omitted, and the outer end cylinder lever is extended sufficiently to couple direct the truck lever, the added length of the cylinder lever r the force transmitted, so that the effect at the brake precisely the same as in the Hodge system. Both syst employed for passenger car brake gear, the prefere either being much a matter of personal choice. W Stevens system is somewhat simpler than the Hodge, th as usually applied to passenger cars, admits of a bett brake gear than the former, and for this reason, is g preferred for this service. Special provision for the the Stevens system is made in the construction of tl matic freight car brake apparatus, by which an equally hand brake gear is had as with the Hodge system.

The peculiar construction of the various classes way vehicles often necessitates modifications of either in the application of the brake gear.

The relative forces existing in the Quick Action Au Brake when applied for a "service" or, an "emergenc are shown in Figs. 7 and 8, with the GIVEN proportion o *resulting from* 70 pounds pressure of air in the train y *auxiliary reservoirs*, rating the air pressure upon the

0 pounds per square inch in a "service," and 60 pounds in an "emergency" application of the brakes. The lesser figures also show the total effect at the brake shoes, when using the old style triple valves with levers of the same proportion.

When applying either system of brake gear to a car, having decided upon the proportions of the truck levers best suited to the car truck, and the total length of the cylinder levers, the following rules may be used in calculating the required proportions of the cylinder lever:

TO FIND THE TOTAL POWER REQUIRED:—Subtract 10 per cent. of the weight of the car AT THE TRACK UNDER THE WHEELS to which brakes are to be applied, for passenger cars, and 30 per cent. for freight cars.

TO FIND THE LEVERAGE REQUIRED:—Divide the total brake power required by the WHOLE pressure on the piston.

TO FIND THE PROPORTION OF THE BRAKE BEAM LEVERS: Divide the WHOLE length of the lever by the short end.

TO FIND THE TOTAL BRAKE BEAM LEVERAGE:—Multiply the proportion of the brake beam lever by two (2) for the HODGE system, and by four (4) for the STEVENS.

TO FIND THE PROPORTION OF CYLINDER LEVER:—Multiply the WHOLE length of the lever by either the REQUIRED leverage or the total brake beam leverage, and divide by the sum of both; the result will give the length of one end of the lever.

If the required leverage is greater than the TOTAL brake beam leverage, the long end of the lever must go next to the cylinder; if less, the short end must go next to the cylinder.

Dead levers must be made in the same proportion as the *ve truck levers.*

EXAMPLE—Hodge System.

Weight of car	40,000	pounds.
" " less 10 per cent	36,000	"
Total pressure on 10 inch piston, (emergency)	4,700	"
Total length of brake beam levers	28	inches.
Length of short end of brake beam lever	7	"
Total length of cylinder levers	24	"

36,000 ÷ 4,700 = 7.66, leverage required.
28 ÷ 7 = 4 × 2 = 8, total brake beam leverage.
24 × 7.66 = 183.84 ÷ (8 + 7.66) = 11.74 short end of cylinder lever.
24 — 11.74 = 12.26, long end of cylinder lever.

EXAMPLE—Stevens System.

Total length of cylinder lever. .... 36 inches.
36,000 ÷ 4,700 = 7.66, leverage required.
28 ÷ 7 = 4 × 4 × 16, total brake beam leverage.
36 × 7.66 = 275.76 ÷ (7.66 + 16) = 11.66, short end of cylinder lever.
36 — 11.66 = 24.34, long end of cylinder lever.

LEVERS.

OR the benefit of those not familiar with the several classes of levers that may be employed in a brake gear for railway ıicles, we have prepared a few simple diagrams Figs. 1, 2, 3, 5 and 6, Plate 4, which will prove of material assistance to :h as may wish to determine for themselves the amount of wer developed by a given series of levers where known ·ces or lengths of levers are given, and from which, by sim- calculations given in the formulæ opposite diagrams 2, 4 d 6, may be found the desired unknown quantity.

There are three kinds of levers, with reference to the re- ive position of the force *F*, weight *W* and fulcrum *C*:

1st. When the fulcrum *C* is between the force *F* and ight *W*, it is a lever of the first kind. Figs. 1 and 2.

2nd. When the weight *W* is between the force *F* and crum *C*, it is a lever of the second kind. Figs. 3 and 4.

3rd. When the force *F* is between the weight *W* and crum *C*, it is a lever of the third kind. Figs. 5 and 6.

The two forces *F* and *W* will be distinguished by con- lering *F* the applied force acting on its lever *L*, to lift the ·ight *W*, acting on its lever *a*. Figs. 1, 2 and 3.

In Figs. 2, 4 and 6, each class of lever is represented as :ached to a brake shoe and suspended opposite a wheel ainst which a force equal to the weight *W* may be expended pressure of a brake shoe upon a wheel, when the applied ·ce *F* actuates the lever in the direction of the arrow.

Lengths of levers are denoted in these diagrams by letters *by substituting* known forces, or lengths, for the lette

used in the formulæ opposite each kind of lever, unkno forces or lengths may be found and thus applied to act practice in determining the proper proportions of levers power braking, to obtain desired results.

The first formulæ opposite the lever of the first kin read "Weight equals F multiplied by b, divided by a," the others in a like manner.

EXAMPLES. FIGS. 1 AND 2.

If a force F of 3,000 pounds is applied at F and the tances or lengths b and a are respectively 18 and 6 incl what would be the weight W, or the pressure of the br shoe against the wheel?

The formulæ given for determining the weight now be used, we have $W = \frac{F \times b}{a}$ and substituting known figures letters, we have $W = \frac{3000 \times 18}{6} = 9{,}000$ pounds.

In this case, we have the force F of 3,000 pounds, weight W of 9,000 pounds, acting upon the lever in the sa direction; hence the sum of the two forces, or 12,000 pou stress is exerted at the fulcrum C, and which may be tra mitted to other levers through properly arranged connecti and further utilized in applying brakes to other wheels un a car.

If the distance b is unknown, and the force F, weight and distance a are known, required distance b; applying

$$b = \frac{W \times a}{F}$$

formulæ and substituting known quantities for letters, we h

$$b = \frac{9000 \times 6}{3000} = 18 \text{ inches.}$$

It will therefore be seen that, by shifting the position of the fulcrum C, a given force F applied as shown in Fig. 1, will within practical limits lift a greater or lesser weight W on the opposite end, and as in Fig. 2 would give a corresponding effect in pressure of the brake shoe against the wheel.

EXAMPLES. FIGS. 3 AND 4.

If a force of 3,000 pounds is applied at F, Fig. 3, and the distances b and a are 24 and 6 inches respectively what is the weight W that can be lifted?

Applying the formulæ, $W = \frac{F \times b}{a}$
and substituting known figures for letters, we have,

$W = \frac{3000 \times 24}{6} = 12{,}000$ pounds, which as applied in Fig. 4, would indicate that the brake shoes may be forced against the wheel with 12,000 pounds pressure.

In this example, we have the force F and the effect at the fulcrum C, acting upon the lever in the same direction, and the weight W in the opposite direction; hence the stress at C must be the weight W, which we ascertained was 12,000 pounds, minus the force F, 3,000 pounds, or 9,000 pounds, a force which may be transmitted to other levers in a system of brake gear as explained in the examples already given for Figs. 1 and 2.

If distance a is unknown, and the force F, weight W and distance b known, and we wish to determine what distance a should be, we have the formulæ, $a = \frac{F \times b}{W}$ and substituting known figures for letters, we have,

$$a = \frac{3000 \times 24}{12{,}000} = 6 \text{ inches.}$$

It will also be observed that with this class of lever, lengthening or shortening distance *a*, enables a given force applied at *F* to lift a lesser or greater weight at *W*, and as applied in Fig. 2, would give a corresponding result in pressure of the brake shoe against the wheel in actual practice.

EXAMPLES. FIGS. 5 AND 6.

Assuming a force *F* of 12,000 pounds, applied at *F*, Fig. 5, and the distance *a* and *b* respectively 30 and 14 inches, what weight may be lifted at *W*, or pressure applied to the wheel by the brake shoe at *W*, Fig. 6 ?

By applying the formulæ $W = \frac{F \times b}{a}$
and substituting known figures for letters, we have,

$$W = \frac{12000 \times 14}{30} = 5{,}600 \text{ pounds.}$$

We have here a force *F* of 12,000 pounds acting upon the lever in one direction, and the weight *W* and effect at fulcrum *C*, in the opposite direction, hence the force or effect at *C* is 12,000 pounds, minus 5,600 pounds or 6,400 pounds.

If we know the length *b*, the force *F* and weight *W*, and wish to find distance *a*, by applying the formulæ, we have,

$a = \frac{F \times b}{W}$ and substituting known figures for letters, we have $a = \frac{12000 \times 14}{5600} = 30$ inches.

These formulæ are equally suitable in ascertaining required forces and distances for other levers forming a part of the brake rigging of a car. If, therefore, the force derived from air pressue at 60 pounds per square inch when using the quick action triple valve, or 50 pounds pressure when using the plain automatic triple valve acting upon the piston of the

rake cylinder is used as a basis of power, the proportion of evers for transmitting the required brake force to the wheels an be readily determined.

The proportions of a lever of the first kind are found by lividing the length of that end of the lever between the fulcrum *C* and the weight *W* into the length of the opposite end. For example: If length *a* is 6 inches, and length *b* 18 inches, the lever is said to be 3 to 1, and a weight equal to three times the force applied at *F* may be lifted at *W*.

The proportions of a lever of the second kind can be found by dividing the length of the end of the lever between the fulcrum *C* and weight *W* into the total length of the lever. For example: If length *a* is 6 inches, and *b* 30 inches, the lever is said to be 5 to 1, and a weight *W* may be lifted at *W*, equal to five times the force applied.

The proportions of a lever of the third kind are found by dividing the total length of the lever into the length of the end between the fulcrum *C* and the force *F*. For example: If the total length of the lever is 30 inches and the length *b* is 24 inches, the lever is said to be $\frac{8}{10}$ to 1, and a weight *W*, equal to $\frac{8}{10}$ of the force *F* applied at *F* may be lifted at *W*.

BRAKE POWER.

IT IS of the utmost importance that the braking force applied to the wheels of a car should be proportionate to the weight of the same ON THE TRACK UNDER THE WHEELS TO WHICH BRAKES ARE APPLIED.

In properly understanding the term "weigh on track under wheels to which brakes are applied;" say we have a passenger car weighing 72,000 pounds with six-wheeled trucks, or the entire weight resting on 12 wheels. If we apply brake shoes to but 8 wheels out of the 12, we cannot figure on 90 per cent. of 72,000 pounds, as the entire weight rests on 12 wheels, which is 6,000 pounds per wheel; hence the total weight resting on the 8 wheels is 48,000 pounds, which represents the "weight on the track under the wheels to which the brake shoes are applied," and in accordance therewith, we must figure on a braking power equal to 90 per cent. of 48,000 pounds, instead of 90 per cent. of 72,000 pounds. In other words, we get a braking power equal to 43,200 pounds, when we should have a braking power of 64,800, if brake shoes were applied to all the wheels under a 72,000 pound car.

Practically, a brake force applied to the wheels equal to the weight that is pressing them against the rail, thus balancing their adhesion to the track, will, at a low rate of speed, cause them to slide, but this may be entirely avoided by properly proportioning the levers, and maintaining the air pressure STRICTLY TO A POINT NOT TO EXCEED THE LIMIT ALLOWABLE, *AND FOR WHICH* THE MAXIMUM POWER OF THE BRAKE HAS *BEEN CALCULATED.*

Practical experience has demonstrated that a total brake rce equal to $\frac{9}{10}$ or 90 per cent. of the weight of the car at the ieels upon which the brakes act, may be safely used with actically no sliding under ordinary conditions of track, and s been adopted as our standard when applying brakes to ssenger equipment cars. In order to further reduce the ding of wheels of freight cars, it is recommended that $\frac{7}{10}$ or ' per cent. of the weight of this class of car be used as a aking force. This was the brake force used on the cars of e Westinghouse experimental train with perfectly satisfac- ry results, as will appear in a tabulated statement on another ge, showing a record of stoppages made by this train under rious conditions of speed and gradient.

Seventy (70) pounds pressure of air per square inch, is iiformly recommended for passenger and freight train service. ie maximum brake force, or, cylinder power, will, in this ork, be understood, unless otherwise specifically stated, as e result of 70 pounds TRAIN PIPE AND AUXILIARY RESERVOIR ESSURE. When using the Engineer's Brake and Equalizing ischarge Valve already described, an excess pressure in the ain reservoir, of 20 to 25 pounds greater than train pipe essure is available, but is used only in releasing the brakes.

Two distinct methods of applying the brakes have already en referred to as "service" and "emergency" applications; e former causing a gentle and gradual application of the akes for ordinary station stoppages, and the latter an instan- neous application of the brakes to the full force in impending inger, and should be used only as such under these conditions.

If in a service application of the brakes, 20 to 25 pounds *air pressure is* gradually discharged from the train pipe

the atmosphere, air pressure from the auxiliary reservoir only is admitted to the brake cylinder, giving about 50 pounds pressure per square inch upon the piston. The dimensions of the auxiliary reservoir used with any of the several sizes of brake cylinders, (excepting that shown in Plate D34, 1890 Catalogue, which is a special short stroke apparatus,) are designed to store a relatively large amount of air, which, when permitted to freely flow and expand into the brake cylinder, will equalize to about 50 pounds pressure.

It will therefore be clearly apparent that, after having reduced the pressure in the train pipe 20 to 25 pounds, by the gauge, the greatest pressure possible is obtained in the brake cylinder, and that any further reduction is an absolute loss and waste of air.

If, when making an emergency application of the brakes, 10 to 12 pounds of air is quickly discharged from the train pipe to the atmosphere, the quick action mechanism of the triple valve is brought into operation, opening passages from the BRAKE PIPE AND AUXILIARY RESERVOIR into the brake cylinder, and the combined volume of air from each receptacle will give about 60 pounds pressure upon the piston, or about 20 per cent. more than in "service" applications.

It will also be apparent that the maximum pressure upon the piston is had from an emergency application of the brakes, and that the power from the service application, used in ordinary station stoppages, while ample for all purposes, is considerably below the maximum power of the brakes, and *will necessarily* result in lessening the number of slid flat *wheels. Sixty* pounds pressure multiplied into the area of the *iston, gives* a force from the 14 inch cylinder of about 9,200

ounds, from the 10 inch cylinder 4,700 pounds, from the 8 ich cylinder 3,000 pounds, and from 6 inch cylinder 1,700 ounds.

When using the plain automatic triple valve with which, s stated, 50 pounds pressure only is obtained in the brake ylinder, the force from each of the cylinders referred to will e about 7,700, 4,000, 2,500 and 1,400 pounds respectively.

The following table will show the resulting pressure in ie brake cylinder from the exhaust or discharge of air from he main brake pipe, two pounds at each discharge, and is he result of actual experiment, the brake cylinder piston raveling 8 inches:

POUNDS PRESSURE.			TOTAL FORCE FROM PISTON. POUNDS.			
Per sq. in. in Brake Pipe.	Exhausted from Brake Pipe.	On Brake Cylinder Piston.	14 in. Cylinder.	10 in. Cylinder.	8 in. Cylinder.	6 in. Cylinder.
70						
63	7	4	600	300	200	100
61	9	19	2,900	1,500	950	500
59	11	26	4,000	2,050	1,300	700
57	13	40	6,150	3,150	2,000	1,100
55	15	46	7,100	3,600	2,300	1,500
53	17	50	7,700	4,000	2,500	1,400
51	19	50				
49	21	50				
47	23	50				

The Westinghouse Quick Action Automatic Brake.

INSTRUCTIONS.

GENERAL. This brake is wholly automatic, and while capable of being operated in harmony with the plain automatic form still in extensive use, it cannot, as was possible with the plain form, be used as a non-automatic brake.

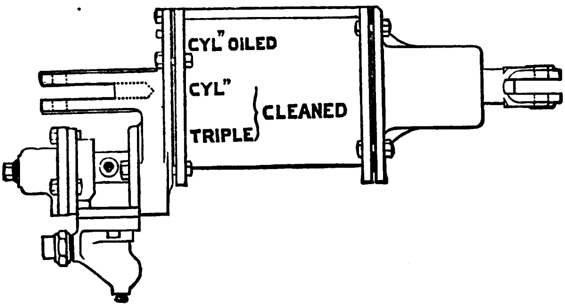
In making up trains, all couplings must be united so that the brakes will apply throughout the entire train. The cocks in the main train pipe must all be opened, except that on the rear of the last car, which must be closed. The cut-out cocks in the branch pipes connecting the main train pipe with the triple valves, must also be opened.

In detaching engines or cars, the couplings must invariably be parted by hand, the cocks in the main train pipe being FIRST CLOSED at the point of separation to prevent application of the brakes. Neglecting this precaution, or opening a valve or cock when the engine is detached, will apply the brakes.

If the brakes are applied when the engine is not attached to the train or car, they can be released by opening the release cock in the bottom of the auxiliary reservoir on passenger cars, and the release valve in the top of auxiliary reservoirs on freight cars.

The adjustment of the brake gear should be such, that when the brakes are fully applied, the pistons in the brake *cylinder will not* have traveled less than 4 inches nor more *than 8 inches.* If the travel is greater than 8 inches, the slack *brake shoes* having been previously adjusted, as would

lone in ordinary practice, it is indicative of weak brake gear, and these parts should be strengthened. Care should be exercised in taking up the slack in the brake connections, to have the hand brakes fully released, the levers and pistons pushed back to their proper places, and the slack taken up by the under connections, or dead levers.



The brake cylinders and triple valves should occasionally e cleaned; the intervals of time between cleanings depending pon the character of the lubricant used and the care taken prevent the entrance of foreign matter into the train pipe. small quantity of 32° gravity West Virginia oil is recommended for oiling brake cylinders and triple valves, which hould be done once in four months. A small syringe of capacity to contain enough oil for one oiling, should be used for onvenience of measurement as to quantity and introduction f oil into the brake cylinder. A record of this work may be eadily kept by stenciling the brake cylinder as shown in the ut *above, and* marking thereon with chalk the last date c *tention given the* apparatus.

When, by reason of accident to the apparatus or brake gear, it is desirable to have the brakes out of use on any particular car, this may be done by closing the cut-out cock. The plain automatic form of triple valve is used for the operation of locomotive driver and tender brakes, and may be rendered inoperative, for a like reason, by turning the handle of the four-way cock, in its construction, downward to a point midway between a horizontal and vertical position, or until a lug on the handle prevents further movement. For the automatic brake, this handle must be placed in a horizontal position.

Triple valves should be drained occasionally, and in cold weather frequently, of any accumulation of water. This may be done by unscrewing the plug in their lower case.

The joints of the air pipes must be kept tight, and when leaks are discovered they should be corrected at the first opportunity. Failure to do so may involve serious detention and unsatisfactory operation of the brakes.

Safety valves should not be used in any portion of the brake apparatus for the relief of surplus pressure, as their use introduces an element of danger which should be avoided. A reasonable amount of care for the pump governor will entirely provide against their necessity, and will stop the pump when the maximum pressure has been accumulated.

Engineers:—A good quality of lubricant should be continuously fed to the steam cylinder of the pump while in operation. A small quantity of 32° gravity West Virginia *well oil should* be used at intervals in the air cylinder, it being *particularly* desirable to use a quality of oil which will cause *the least gummy* deposit in the air passages, reducing their dimensions and preventing the free discharge of air to the main

servoir. Tallow, lard oil or kerosene must not be used in e air cylinder.

Attention is drawn particularly to the description of the ake valve contained in this work, and the fullest advantages ould be taken of the opportunity it affords for the correct eration of the brakes. Care should be taken to discharge c to eight pounds of air by the gauge in the first instance, in plying brakes for ordinary stoppages, which will cause the stons in the brake cylinders to move outward sufficiently to se the leakage groove, forcing the brake shoes lightly ainst the wheels. Further reductions of pressure may there- ter be made to suit circumstances.

The brakes are fully applied when the pressure in the ain pipe, and as shown on the gauge, has been reduced 20 unds. Any further reduction is a waste of air.

It is of great importance that the engineer should remem- r that the gradual application of the brakes is caused by a ntle discharge of air pressure from the train pipe to the at- osphere, and that a rapid discharge causes the quick action the brakes to ensue. It is therefore essential that he ercise some degree of care and moderation in applying akes, taking advantage of the emergency action of the brakes ly when absolutely necessary to avoid accident.

Engineers upon finding that the brakes have been applied the train men, or automatically, must at once aid in stopping e train by using the brake valve as in making ordinary oppages, *which will* prevent the loss of pressure from the *in reservoir and* enable the prompt release of brakes whe *essary.*

It is important that the main reservoir be drained of water at regular intervals, especially in moist climates and seasons. As much of this accumulation is condensed from the steam cylinder and passes into the air cylinder, through imperfectly packed piston stuffing boxes, care should be taken to avoid this.

The shoes of driving wheel brakes should be so adjusted, by means of the cam screws, that the pistons move from 3 to 5 inches when the brakes are applied.

If cars having different air pressures be coupled together, the brakes will apply themselves to those having the highest pressure in the auxiliary reservoirs. To insure the certain release of all the brakes in the train, and also that the reservoirs may be quickly charged, the engineer must carry the maximum pressure in the main reservoir before connecting to a train.

On long down grades, it is important to be able to control the speed of the train, and at the same time to maintain a good working air pressure. This is readily accomplished on ordinary gradients, where the pressure retaining valve is not necessary, by running the pump at a good speed, so that a comparatively high pressure will have been accumulated in the main reservoir while the brakes are on, and which when released enables the auxiliary reservoirs to be speedily recharged before the speed has increased to any considerable extent. It should be sought to control the train on any grade by the use of the smallest quantity of air possible, and the *fewest number* of applications of the brakes.

Train Men and Inspectors:—After making up or adding *to a train*, or after a change of engines, it must be ascertained

ıat the brakes are operative throughout the entire train by ›tual trial before starting, and that the hand brakes are ıtirely released.

When hose coupling are not used for connecting the rakes between two vehicles they must be attached to their ummy couplings.

When occasion arises for applying brakes from the cars, ull open the conductors' valve provided for this purpose, tting the air escape from the train pipe. Having brought e train to a stop, close the valve, which must be done by ınd, and BEFORE the brakes can again be released by the gineer. This method of application should be used only in ses of emergency. The hand brakes must be entirely re- ısed before starting.

THE DISTANCE IN WHICH A TRAIN FITTED WITH ACTION AUTOMATIC BRAKE CAN BE STOP

AS a matter of interest and for reference, a sum results of a series of tests made with an experi of fifty (50) freight cars, equipped with the quick matic brake, is published on the following page. SULTS CAN BE DUPLICATED IN REGULAR RAILWAY SI the data published herewith will serve for desired c

This train consisted of 50 standard Pennsylva 60,000 pounds capacity box cars, weighing ab pounds each. Length of train, about 1,900 feet weight nearly 2,000,000 pounds.

DESCRIPTION OF TESTS.

1. Emergency stops, train running at *2C hour.
2. Emergency stops, train running at *4C hour.
3. Applying brakes while train was standi show rapidity of application.
4. Emergency stops, train running at *4C hour.
5. Service stops, and time of release. Ex smoothness of ordinary stop and time of release.
6. Hand brake stops, at *20 miles per hou *brakeman at* their posts; at Buffalo there were seve *men.*
7. *Breaking* train in two.

SUMMARY OF RESULTS OF TESTS, WITH 50 CAR TRAIN, IN OCTOBER, NOVEMBER AND DECEMBER, 1887.

Place of Test.	Down Grades. Feet per Mile.	First. Miles speed.	First. Feet distance.	First. Sec'ds time.	Second. Miles speed.	Second. Feet distance.	Second. Sec'ds time.	Fourth. Miles speed.	Fourth. Feet distance.	Fourth. Seconds time.	Sixth. Miles speed.	Sixth. Feet distance.	Sixth. Sec'ds time.	Seventh. Miles speed.	Seventh. Ft. distance apart.	Eighth. Miles speed.	Eighth. Ft. distance.	Eighth. Sec'ds time.	Ninth. Miles speed.	Ninth. Ft. distance.	Ninth. Sec'ds time.	Tenth. Miles speed.	Tenth. Fee distance.	Tenth. Seconds time.
St. Paul....	13·6	19	172	7	36	490	15	20 37	200 583	.. ..	..	......	.	25	10.	20	109	..	37	327	..	..	....	....
Chicago....	Level, head wind.	22	184	10	37	480	15	20 34	162 470	11 15	19	1,200	62	20	59	2[illegible]	120	6	33	272	11	..	....	....
St. Louis..	52·8	20	176	11	36	507	18	3[illegible]	502	17	21	2,11[illegible]	128	23	61	2	109	6	38	377	11	..	....	....
Cincinnati..	50·0	25	284	12	35	542	17	37	573	17	21	1,925	75	2[illegible]	32	20	102	6	41	425	12	..	....	....
Cleveland..	40·0	26	265	12	43	718	20	38	636	17	23	1,686	65	25	45	20	96	6	40	375	11	43	767	22*
Buffalo....	32·20	21	214	12	40	679	19	39	648	19	20	1,00[illegible]	48	....	[illegible]9	20	93	6	4[illegible]	414	13	..	....	....
Albany....	35·0	20	158	10	36	560	18	37	5[illegible]	19	20	1,342	60	....	180	19	78	5	40	358	12	..	....	....
Boston....	40·0	19	123	10	32	406	16	34	483	17	21	1,035	54	22	62	20	111	8	..	.....	..	38	319 547	12 17
New York..	53·0	23	203	12	41	674	20	41	672	20	21	2,137	85	....	43	22	91	6	..	.....	..	45	495 1,204	13 27
Philadelphia	44·0	23	264	14	36	593	19	36	579	18	18	1,889	7[illegible]	22	35	20	87	6	..	.....	..	49	647 932	19 23
Washington.	52·0	19	159	1	42	694	21	42	718	21	2[illegible]	1,643	67	23	58	21	81	6	4[illegible]	359	11	..	....	....
Pittsburgh..	47·0	20	194	11	40	649	21	40	673	20	2	1,720	72	....	....	20	95	6	..	....	.	45	494 890	14

*Passenger train only. Compare with freight train in Test No. 9.
THIRD TEST.—In all cases the brakes went fully on within two seconds.
FIFTH TEST.—The brakes were released in all cases in four seconds.

All of the foregoing stops were made with the braking power so low that it would not slide wheels in regular service. By using a greater power, quicker stops could be made, but it would result in a greater possibility of slid wheels.

8. Emergency stop at *20 miles per hour; the brake leverage having been increased to give the quickest time possible.

9. Emergency stop at *40 miles per hour; same leverage as in number 8.

10. A train of 20 freight cars, and a train of 12 ordinary passenger coaches, run alongside of each other, on parallel tracks, each being about the same weight and length of train, and the brakes applied at the same time. This test shows the relative stopping power of the old and the new brake.

It is sometimes important to know the distance in which a train should be stopped at a greater or lesser speed, all other things being equal, the distance and speed of any one stop being known. This may be determined by applying the following rule: MULTIPLY THE KNOWN DISTANCE, BY THE SQUARE OF THE SPEED FOR WHICH PROPORTIONATE DISTANCE IS DESIRED, AND DIVIDE THE PRODUCT BY THE SQUARE OF THE SPEED AT WHICH KNOWN STOP WAS MADE.

For example: If a train at a speed of 20 miles per hour was stopped in 102 feet, in what distance should it be stopped at a speed of 41 miles per hour.

$$\textit{Square of } 20 = 400$$

$$\textit{Square of } 41 = 1681$$

$$\frac{1681 \times 102}{400} = 428 \textit{ feet.}$$

*Speed attempted; actual speeds attained are given in statement and as read from speed gauge on engine. Fractions of miles and seconds are omitted in the statement. Two engines were used in making all of the tests at St. Paul, and one engine in all other tests.

THE WESTINGHOUSE AIR BRAKE CO.

SUPPLEMENT No. 1

TO

INSTRUCTION BOOK.

THE NINE AND ONE-HALF INCH IMPROVED AIR PUMP.

As will be seen by reference to Figs. 1 and 2, Plate 5, the valve motion of the pump consists of two pistons 77 and 79 of unequal diameter, mounted on rod 76, while a slide valve 83, of the D type, held in position between them, provides for the distribution of steam to the upper and lower sides of main steam piston 65, as required. Steam enters the pump at X where a suitable stud and nut admits of the direct attachment of the pump governor, and by means of passages a and a^1, and port a^2 is admitted to slide valve chamber A between the two pistons 77 and 79, where by reason of the greater area of the former, tends to force it to the right to the position in which the valve is shown in Fig. 1, thus admitting steam to the under side of main piston 65 through port b and passages b^1 and b^2 forcing it upward, while the steam previously used on the opposite side in forcing the main piston downward is exhausted to the atmosphere through passage c, port c^1, cavity B of the slide valve 83, port d and passage d^1 and d^2 at the connection Y from whence it is conveyed by suitable pipe to the smoke box of the locomotive.

In Fig. 3 is illustrated an outside view of main valve bushing 75 showing the several ports and steam passages

therein, of which port t communicates between chamber E in the main valve head 85 and exhaust passage f^1 and hence is in constant communication with the outside atmosphere, relieving the pressure on the surface of main valve piston 79 exposed to chamber E. A reversing valve 72 operates in chamber C in the center of the steam cylinder head, steam being supplied thereto from slide valve chamber A through ports e and e^1 and which is given motion through the medium of a rod 71 extending into the space k of the hollow main piston rod. The duty of this valve is that of admitting steam to and exhausting it from space D between main valve piston 77 and the head 84 and is shown in Fig. 2 in position to exhaust the steam previously used, from the space D through port h, (Fig. 3) port h^1, reversing valve cavity H and ports f and f^1 to the main exhaust ports d and d^1 and d^2.

It will at once be apparent having described how the surface of main valve pistons 77 and 79 exposed in chambers D and E respectively, being free from pressure other than the outside atmosphere, that the steam on the opposite side in chamber A, is exerting a force in both directions, but the total force toward the right is greater by the sum of the steam pressure in chamber A multiplied into the difference between their areas. This effect, however, is reversed when the main piston, approaching the upward termination of its stroke, strikes the shoulder j of the reversing valve rod 71 forcing the rod

and its valve 72 upward causing the admission of steam from chamber C to chamber D through ports g and g^1, (Fig. 3), thus balancing the pressure on both sides of main valve piston 77, when the steam in chamber A acting upon the effective area presented to it, of main valve piston 79, forces it to the left and live steam is again admitted to the upper side of main steam piston 65 exhausting from the opposite side, and forcing it downward until at the lower termination of its stroke the button head on the lower end of the reversing valve stem 71 comes in contact with reversing valve plate 69, again moving reversing valve 72 to the position shown in Fig. 2, completing the cycle of its movement.

Coincident with the reciprocal movements of the main steam and air pistons, air from the outside atmosphere is drawn alternately into the respective ends of the air cylinder 63, through the screened inlet 106 at W, chamber F, and receiving valves 86 to the left, Fig. 1, and from thence discharged under pressure through discharge valves 86 to the right, Fig. 1, to chamber G and the main reservoir to which the pump should be connected by one and one-fourth inch pipe at Z. The lift of receiving and discharge valves 86 should be three thirty-seconds of an inch.

The same care should be given this pump as that recommended for the Eight Inch now in almost universal use. The

admonition however, to use *only a moderate quantity of oil* in both the steam and air cylinders will bear repeating. Ample provision is made for drainage by means of two cocks, 105, located in the steam passage *a* and b^2.

The larger sizes of pipe connections for this pump have necessitated the manufacture of a suitable one inch throttle valve, one inch pump governor and one and one-fourth reservoir union, all of which will be found illustrated in Supplement No. 1 to the 1890 Catalogue.

IE IMPROVED ENGINEER'S BRAKE AND EQUALIZING DIS-CHARGE VALVE, WITH FEED VALVE ATTACHMENT.

In the construction of the new Engineer's Brake and qualizing Discharge Valve, with Feed Valve attachment, illus-ated in Figs. 4, 5 and 6, Plate 5, two important improvements ve been made, one operative and the other constructive.

In operation, this valve is so arranged that when the ndle is in "Running Position," the pressure in the train pe is automatically cut off when it reaches 70 pounds, regard-ss of any higher pressure that may be in the main reservoir, d any loss in the train pipe, due to leakage, is automatically pplied. The amount of excess pressure to be carried in the ain reservoir for the purpose of recharging and releasing omptly, is regulated by the pump governor, which is adjusted stop the pump when the maximum pressure has been reached erein. The construction of the previous engineer's brake and ualizing discharge valve (Plate D8) is such that when the handle in "Running Position," the regulation of pressure in the train pe is dependent upon the operation of the pump governor, d the amount of excess pressure in the main reservoir is ntrolled by what is called an excess pressure valve, but

which is more accurately described, as a valve for creating a predetermined difference of pressure between the main reservoir and train pipe. This valve is usually so adjusted that when a pressure in the main reservoir of 20 lbs. in excess of that in the train pipe is reached, it will open and supply air to the train pipe, but no communication between the main reservoir and the train pipe exists until this difference in pressure is secured. It is therefore evident that when the handle of the engineer's valve is returned to "Running Position," after having been placed in "Position for Releasing Brake," (in which latter position the pressure in the main reservoir and train pipe equalizes,) it is necessary to accumulate an excess pressure of 20 pounds in the main reservoir, before air can pass the excess pressure valve to supply any deficiency in the train pipe, due to leakage or the charging of auxiliary reservoirs.

From the above explanation it will be seen that the differences in operation between these two valves, are,

First.—With the new valve air is automatically supplied to the train pipe until 70 pounds pressure is reached, if there is a pressure of 70 pounds or greater in the main reservoir. Train pipe pressure in the previous valve is regulated by the pump governor. We therefore dispense with the pump governor for the purpose of controlling train pipe pressure with the new valve.

Second.—With the new valve, when the handle is in "Running Position," provision is made for constantly supply-

ing the train pipe with air for any loss of pressure due to leakage at the pipe joints or from other sources. With the old valve, it is necessary to have an excess pressure in the main reservoir of not less than 20 pounds, before air can be supplied to the train pipe for the purpose of compensating for leakages when the handle of the valve is in "Running Position."

Third.—With the new valve, the only duty of the pump governor is to regulate the degree of excess pressure in the main reservoir, and as this may, and often should be, varied within considerable limits, the sensitive and delicate operation of the pump governor is not essential. A desired variation of excess pressure is readily had by an adjustment of the tension nut of the governor spring. With the old valve, the governor regulates train pipe pressure, and accurate adjustment is imperative to accomplish effective braking. Excess pressure is regulated by the tension of a spring controlling an excess pressure valve, and cannot be changed except by the substitution of different springs and a readjustment of the pump governor.

Constructively, the principal feature of the new valve is an opportunity for the removal of all of the operative portions for inspection or repair, without breaking or disturbing any of the pipe connections. The main rotary valve and its seat are made of different metals which reduces the effect of wear to a minimum.

Pipe connections must be made to the main reservoir at X, to the train pipe at Y, to the equalizing reservoir at T, and to the duplex gauge at R and W, respectively for main reservoir and train pipe pressures. The gauge pipe from R should be extended to the air pump governor, which latter device should be set to stop the pump at about 85 to 100 pounds pressure, thus providing for an excess pressure in the main reservoir of 15 to 30 pounds above standard train pipe pressure of 70 pounds per square inch. The amount of excess pressure required depends upon the length of trains and character of the road—whether level or with long and severe grades. Ordinarily 15 to 20 pounds excess pressure is ample for the safe operation of brakes on the ordinary railway.

While the handle is in position 1, "For Releasing Brakes," air from the main reservoir enters the brake valve at X, passing through ports A,A, thence through port *a* in the rotary valve 43 to the port *b* in its seat 33, thence upward into cavity *c* of the rotary valve, and finally to ports *l* and l^1 and the train pipe at Y. Port *j* in the rotary valve and *e* in its seat are in register in this position, and admit air to chamber D above equalizing piston 47, and passing thence through ports *s* and *s*, charges the small equalizing reservoir connected at T. The train pipe and auxiliary reservoirs of the brake apparatus being charged, the handle 38 of the brake valve being moved to 2, "Position While Running," ports *a* and *b*, and *j* and *e*, are no longer in

communication, and air then reaches the train pipe through port *j* in the rotary valve 43, and ports *f* and f^1 in its seat 33, passing thence through feed valve 63 to port *i*, ports *l* and l^1 to the train pipe, and continues to flow thereto until the pressure in chamber B upon diaphragm 72 exceeds the resistance of spring 68, and, forcing the diaphragm and its attachments downward, feed valve 63 closes until such time as by reason of any leaks in the train pipe the pressure therein has been reduced below 70 pounds, when the valve 63 is again automatically pushed open by the diaphragm rising, replenishing train pipe pressure. Equalizing port *g* is now in communication with chamber D, maintaining train pipe pressure therein, through ports l^1, *l* and cavity *c* in the rotary valve 43. The necessary adjustment of spring 68 is readily accomplished by means of adjusting nut 70, to which access is had by the removal of cap check nut 71.

To apply brakes, the handle 38 of the valve is moved to position 4, "Application of Brake—Service Stop," bringing into conjunction port *p* (a groove in the under side of rotary valve 43) and ports *e* and *h* (the latter also a groove) in its seat, causing air to any desired extent to be discharged to the atmosphere from the chamber D above piston 47 and the Equalizing Reservoir, through the large direct application and exhaust port *k*, thus reducing the pressure above piston 47 and causing that in the train pipe below

to force it upwards from its seat, permitting air to flow from the train pipe through ports m, n and n^1 to the atmosphere through exhaust connection 51. The desired reduction or pressure in chamber D being made, the handle of the valve is moved backward to position 3, "On Lap." It must be borne in mind that after the handle of the valve has been moved to lap position, air will continue to flow from exhaust fitting 51 until the pressure in the train pipe has been reduced to an amount approximating that in chamber D. Ordinarily, a reduction of 6 to 8 pounds pressure by the gauge from chamber D is sufficient to apply the brakes in the first instance slightly, and will cause a corresponding reduction of train pipe pressure by the rising of piston 47, which latter, when such reduction has taken place, is automatically forced to its seat by the preponderence of pressure on its upper surface from air remaining in chamber D.

The release of the brakes is effected by moving the valve handle 38 to "Position for Releasing Brake," causing air from the main reservoir to again freely flow to the train pipe, forcing the triple valve pistons to release position and exhausting air used in applying the brakes, and recharging the Auxiliary Reservoirs. While the handle of the Valve is in this position a "Warning Port" of quite small size causes air from the Main Reservoir to be discharged to the atmosphere with considerable noise, attracting the Engineer's attention to his neglect

to move the Valve Handle to "Running Position." The Engineer must move the handle of the Brake Valve from position 1 to position 2 prior to the accumulation of the maximum pressure of 70 pounds allowed in the train pipe, so that the Feed Valve Attachment may properly perform its functions of governing train pipe pressure; otherwise the priviledged pressure in the train pipe may be considerably augmented, which must be carefully avoided. With trains of ordinary length it will be found that the brakes can be readily released and the Auxiliary Reservoirs promptly recharged by simply returning the handle to "Running Position" (2).

For an emergency application the handle 38 of the Brake Valve is moved to the extreme right, position 5, "Application of Brake—Emergency stop," when "direct application and exhaust port" *k* and "direct application and supply port" *l* are brought into conjunction by means of a large cavity *c* in the under surface of the Rotary Valve 43, thus admitting of the discharge from the train pipe of a large volume of air to the atmosphere, causing the quick action of the brakes. Such action, however, should be employed only in an emergency. A reduction of 20 to 25 pounds pressure in the train pipe at the Brake Valve is sufficient to apply the brakes to their maximum, and any further reduction of pressure is consequently a waste of air. It will be noted that THIS VALVE IS MANIPULATED IN THE SAME MANNER AS THE PRECEDING PAT-

TERN, AND THAT ADDITIONAL INSTRUCTIONS IN THIS RESPECT TO ENGINEERS ARE UNNECESSARY.

An Excess Pressure Valve arrangement, illustrated in Fig. 8, may be substituted for the Feed Valve if desired, restoring that feature substantially as arranged in the Plate D8 form of Engineer's Brake Valve, and in that event the Pump Governor should be similarly connected to the Train Pipe, and for which purpose suitable provision is made when new brake valves are ordered accordingly.

By preparing a diagram of tracing cloth or gelatine similar to Fig. 7, and placing it in a reversed position on Fig. 5, where it may be rotated on a centre, the forgoing explanation may be followed with ease by those interested.

The same directions for erecting, as given for the Plate D8 Engineers' Brake Valve, should be followed in case of the new valve just described.